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Revolutionizing Healthcare Delivery with Blockchain Technology

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Abstract

Medical drones are used to transport medical supplies, equipment, and personnel to remote and underserved areas, providing life-saving assistance to communities in need. However, the current system of medical supply chains is often inefficient and prone to errors, with little transparency and accountability. By incorporating blockchain technology into the medical drone system, it is possible to improve the transparency and security of medical supply chains, as well as the tracking and monitoring of medical drones. Blockchain can be used to securely store and manage information about medical drone deliveries, including the origin and destination of the drones, as well as the type and quantity of medical supplies being transported. Additionally, blockchain can also be used to manage payments for medical drone services, ensuring that payments are securely and transparently processed, tracking the maintenance and repair of medical drones, and ensuring that they are in good condition and safe to use. In conclusion, the implementation of medical drones using blockchain technology has the potential to greatly improve the efficiency, security, and transparency of medical supply chains. This can help to ensure that medical supplies and equipment reach their intended destination.

Keywords: Healthcare, Blockchain, Healthcare delivery.

1 | Introduction

Technological advances have resulted in numerous innovative solutions to various challenges in various fields in recent years. The use of medical drones in the healthcare industry is one such solution. Medical drones are Unmanned Aerial Vehicles (UAVs) that are outfitted with medical supplies, equipment, and technology to provide individuals in need with quick and efficient medical care. Medical drones are celebrated as the future of healthcare delivery, potentially saving lives in emergencies and improving access to healthcare in remote and underserved areas [1–3]. Drones have enormous potential for delivering critical goods to vulnerable populations, overcoming access barriers, and allowing for faster delivery of life-saving medicine. Drones can

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bridge the gap between urban and rural medical facilities by providing critical and timely medical care to people in remote areas. Healthcare organizations already use mobile technology to solve some of the industry's problems. Mobile devices, wearable technology, remote monitoring, telemedicine, and information-sharing platforms are transforming healthcare. Drones, robots, and artificial intelligence will likely take over many healthcare tasks that humans currently perform in the near future, reducing variability, cost, and error.

Drones make it possible to deliver blood, vaccines, birth control, snake bite serum, and other medical supplies to rural areas and can reach victims who require immediate medical attention within minutes, which in some cases could mean the difference between life and death. They can transport medicine within hospital walls, courier blood between hospital buildings, and give elderly patients tools to support them as they age. Metropolitan cities like Chennai, Hyderabad, Mumbai, Delhi, Banglore, etc., face many traffic issues across the state. Whenever there is an emergency in a particular area, these drones can be beneficial to deliver emergency meds to first aid the patient [4].

Approximately 30,000 government-run primary healthcare centers serve the majority of India's 1.4 billion citizens, but at least 5-10% are inaccessible to medical suppliers due to geographic location and natural disasters. According to Global Market Insights, the medical drone market will reach $399 million by 2025, with advances in drone hardware and software driving this growth.

In this article, we will look at the many advantages and potential applications of medical drones in the future.

2 | Existing Methodology

2.1 | Implementation of MATLAB in Medical Drone Delivery

MATLAB is a programming language widely used in the medical drone field. Medical drones, also called UAVs, are assembled with various sensors, such as cameras and infrared sensors, which capture real-time data from remote areas to medical facilities. MATLAB can be used to develop the algorithms and process the data collected by the drone [5].

MATLAB and Simulink provide capabilities to speed up the development of the UAV. This MATLAB application can analyze any UAV system architecture and design algorithms for flight controllers. They are also used to control UAVs and analyze the data present in the UAV.

MATLAB allows you to design and develop flight controller algorithms without hardware and reduce risk. Using the MAV link communication protocol, you can connect to common UAV autopilots and UAV hardware and analyze the flight data using respective applications. Somehow, MATLAB can be used to develop control systems for medical drones, such as navigation and obstacle hindrance systems [6]. These systems allow drones to fly safely with precautions, navigate to the location, identify the recipient, and deliver medical supplies to remote areas or other hospitals where needed.

The MATLAB software can be used to create a control system for the drones that allows the drone to fly safely and avoid obstacles, ensuring safe passage to deliver the meds package. Testing and validation are significant parts of the MATLAB software that ensure the drone is secure, reliable, and accurate. The MATLAB can also be used for data analysis and optimization. For example, it can be used to optimize the drone's flight path to minimize the delivery time and energy consumption and improve its performance.

In summary, MATLAB is used in medical drones to develop algorithms, software, and control systems that allow drones to collect, process, and analyze medical data as well as safely deliver medical supplies and equipment to remote areas.

2.2|Why Blockchain Technology is Implemented in Place of MATLAB Software?

Blockchain technology and MATLAB software are two different technologies with different specifications. While MATLAB is a software for computation and data visualization, Blockchain technology is a decentralized and distributed ledger that allows for secure and transparent transactions between multiple parties without intermediaries. With its ability to provide immutable and transparent records, blockchain is being explored for various use cases, including the implementation of medical drones.

Medical delivery drones require secure and reliable communication systems to ensure the safe and efficient delivery of medical supplies, vaccines, and other critical items. Blockchain technology provides a secure and transparent transaction tracking and verification platform, making it an ideal choice for medical delivery drone implementation [7–10].

In summary, while MATLAB software can be used to improve the performance of medical delivery drones, blockchain technology is used in place of MATLAB software to ensure the secure and efficient delivery of critical medical supplies.

3|Blockchain Technology in Medical Drones

Blockchain technology can be used to build a decentralized network of drones and medical facilities, allowing for the secure and efficient tracking of medical supplies from the point of origin to the destination. This helps to ensure the safe delivery of critical medical supplies, especially in areas with limited infrastructure and healthcare resources.

Blockchain technology can also create smart contracts that automate the delivery process, ensuring that medical supplies arrive at their destination without human intervention. This reduces the risk of errors and fraud while also increasing the overall efficiency of the delivery process.

By implementing blockchain technology, medical drone networks can address these challenges by providing an immutable and transparent record of every transaction in the supply chain. This record can help ensure regulatory compliance and traceability and enhance security and trust in the system [11].

Moreover, blockchain technology enables secure and decentralized data sharing between stakeholders, including patients, medical professionals, and drone operators. This can enhance collaboration, improve patient outcomes, and ensure privacy and security of sensitive medical data.

Furthermore, blockchain technology can be used to facilitate the exchange of value between various parties involved in medical delivery drones, such as hospitals, pharmacies, and patients. When combined with cryptocurrencies or digital tokens, blockchain technology can provide a secure and efficient system for making payments and tracking transactions.

Medical drones have the potential to revolutionize healthcare delivery by enabling rapid and efficient delivery of medical supplies and equipment to remote and hard-to-reach areas. However, challenges such as regulatory compliance, security, and trust need to be addressed.

Blockchain ensures regulatory compliance that can help to ensure that medical drone operations comply with local regulations and standards by creating an immutable record of drone activities. Blockchain technology can be crucial in implementing medical drones by addressing regulatory compliance, security, and trust issues while enabling secure and transparent data sharing between different stakeholders. It can help enhance the capabilities of medical drones by providing safe and efficient data transfer, tracking of medical supplies, optimization of delivery routes, and automated payment processes [12].

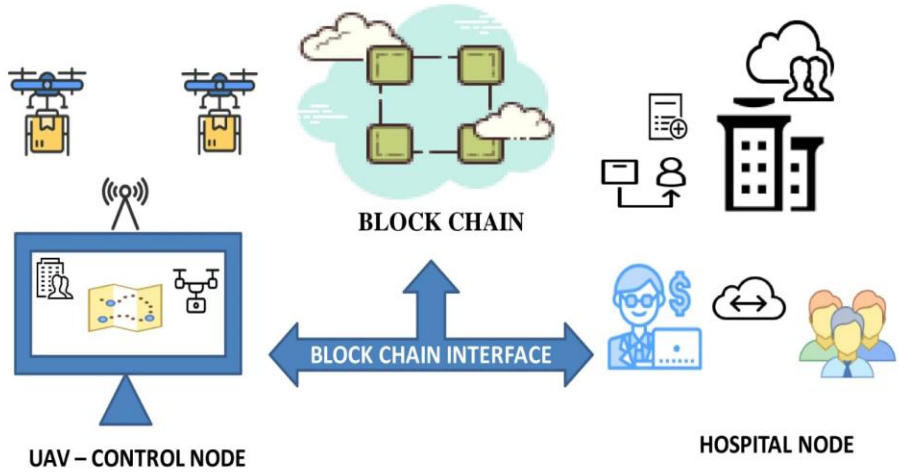

Fig. 1. Blockchain Interfaces.

4 | Proposed Solution

The block diagram comprises a blockchain network, UAV control node, hospital node, blockchain interface, flight control logic, intelligent contract logic, simulation and testing environment, and autonomous flight algorithm development.

UAV control node: the UAV control node is a component in the block diagram of a blockchain implementation in MATLAB and Simulink for UAV and autonomous flight applications. This node is responsible for controlling the UAV's flight based on commands from the hospital node and for managing smart contracts that enable secure and efficient drone operations. The UAV control node includes several subcomponents:

I. Blockchain interface: this subcomponent interacts with the blockchain network to enable secure and efficient communication and transactions between the UAV and hospital nodes.

II. Flight control logic: this subcomponent controls the UAV's flight based on commands from the hospital node. It ensures the UAV follows a safe and efficient flight path and lands safely.

III. Smart contract logic: this subcomponent manages the smart contracts that enable secure and efficient drone operations. It ensures that the UAV follows the terms of the smart contracts and that the transactions are executed as expected.

Together, these subcomponents enable the UAV control node to efficiently and securely interact with the hospital node and the blockchain network and to safely and efficiently control the UAV's flight operations.

The hospital node: the hospital node is a component in the block diagram of Blockchain implementation in MATLAB and Simulink for UAV and autonomous flight applications [13], [14]. This node is responsible for initiating and managing medical supply orders and interacting with the UAV control node to coordinate the delivery of medical supplies. The hospital node includes several subcomponents:

I. Blockchain interface: this subcomponent interacts with the blockchain network to enable secure and efficient communication and transactions between the hospital node and the UAV control node.

II. Medical supply orders: this subcomponent manages the medical supply orders that the hospital initiates. It ensures that the orders are properly recorded and tracked on the blockchain.

III. Payment transactions: this subcomponent manages the payment transactions associated with the medical supply orders. It ensures that the payments are executed securely and efficiently on the blockchain.

Together, these subcomponents enable the hospital node to efficiently and securely manage medical supply orders and payments and to interact with the UAV control node to coordinate the delivery of medical supplies.

5 | Stimulation and Testing

The Simulation and Testing component is a part of the block diagram of blockchain implementation in MATLAB and Simulink for UAV and autonomous flight applications [15]. This component is responsible for simulating and testing the UAV's flight and the blockchain network's behavior, which enables developers to validate the system's functionality and identify potential issues before deployment. The Simulation and Testing component includes several subcomponents:

Simulation environment: this subcomponent creates a simulated environment for the UAV's flight and the blockchain network's behavior. It enables developers to test various scenarios and configurations to ensure the system works as expected.

Code

```
% Initialize the blockchain network
bc = blockchain.createBlockchain();
% Initialize the UAV control node
uavNode = createUAVControlNode(bc);
% Initialize the Hospital node
hospitalNode = createHospitalNode(bc);
% Initialize the simulation environment
env = simEnvironment();
% Run the simulation
while (env.time < env.endTime)
% Update the UAV control node's flight status and check for new orders
uavNode.updateFlightStatus();
uavNode.checkForNewOrders();
% Update the Hospital node's order status and check for payment transactions
hospitalNode.updateOrderStatus();
hospitalNode.checkForPayments();
% Update the UAV's position based on the autonomous flight algorithm
uavNode.updatePosition();
% Check for obstacles and adjust flight path as necessary
uavNode.avoidObstacles();
% Update the blockchain network
bc.updateNetwork();
% Update the simulation environment
env.update();
end
```

6 | The Environment of MATLAB/Simulink

The Environment (MATLAB/Simulink) component is a part of the block diagram of blockchain implementation in MATLAB and Simulink for UAV and autonomous flight applications. This component provides the development environment for the simulation and testing of the UAV's flight and the blockchain network's behavior, as well as for developing the autonomous flight algorithm. The Environment (MATLAB/Simulink) component includes several subcomponents:

I. MATLAB: this subcomponent is a programming language that provides a high-level simulation, testing, and algorithm development environment.

II. Simulink: this subcomponent is an environment for simulation and model-based design of dynamic systems, such as the UAV's flight and the blockchain network's behavior.

III. UAV flight simulation model: this subcomponent is a model of the UAV's flight dynamics, which enables developers to simulate the UAV's flight in various scenarios. Together, these subcomponents enable developers to efficiently and effectively develop and test the UAV's flight and the blockchain network's behavior and develop and refine the autonomous flight algorithm.

IV. Testing framework: this subcomponent provides tools for automated testing and validating the system's functionality. It enables developers to identify potential issues and track the system's performance over time. Together, these subcomponents would allow developers to efficiently and effectively test the system's functionality and identify potential problems before deployment, which improves the system's reliability and reduces the risk of failure.

Together, these subcomponents enable developers to efficiently and effectively develop and test the UAV's flight and the blockchain network's behavior and develop and refine the autonomous flight algorithm.

The distance between the medical drone and the patient's location can be determined by following.

$$\text{Distance} = \text{sqrt}((x2 - x1)^2 + (y2 - y1)^2).$$

where (X1, Y1) are the coordinates of the medical drone and (X2, Y2) are the coordinates of the patient

The payload capacity is "The maximum weight that the medical drone can carry," and the formula to calculate the payload capacity is given as follows:

$$\text{Payload capacity} = (\text{Drone's lift capacity}) - (\text{Weight of the drone}) / \text{Payload weight}.$$

The time the medical drone can stay in the air is known as "Flight Time". These medical drones should ensure they reach the patient and return to the home point before the battery drains out. Therefore, the flight time can be calculated as

$$\text{Flight time} = (\text{Battery capacity}/\text{power consumption per minute}) * 60.$$

Where the battery capacity is the total amount of energy that the battery can store and the power consumption per minute is the amount of energy that the drone uses per minute of flight. The weight capacity formula can be used to calculate the maximum weight that a medical drone can carry. It is derived as

$$W = F * g.$$

Where "W" is the weight of the drone, "F" is the lifting force of the drone, and "g" is the acceleration due to gravity.

The most important accessory is the Battery Life. The battery life formula calculates the Maximum flight time of a medical drone. It is given as

$$T = E / P.$$

Where "T" as the flight time, "E" is the energy stored in the battery, and "P" is the power used by the drone.

7 | Autonomous Flight Algorithm

The autonomous flight algorithm development component is a part of the block diagram of blockchain implementation in MATLAB and Simulink for UAV and autonomous flight applications. This component is responsible for developing the algorithms that enable the UAV to navigate and perform its mission autonomously. The Autonomous Flight Algorithm Development component includes several subcomponents:

I. Obstacle avoidance: this subcomponent is responsible for detecting and avoiding obstacles in the UAV's path. It includes algorithms such as sensor fusion and path planning.

II. Mission planning: this subcomponent is responsible for planning the UAV's mission, including selecting waypoints and determining the optimal path to reach them.

III. Path following: this subcomponent enables the UAV to follow the planned path accurately. It includes algorithms such as control and estimation. These subcomponents enable the development of the autonomous flight algorithm, which enables the UAV to navigate and perform its mission autonomously.

Using blockchain implementation in MATLAB and Simulink, developers can efficiently and effectively develop, test, and refine the autonomous flight algorithm, improving the UAV's reliability and reducing the risk of failure. In conclusion, the block diagram of blockchain implementation in MATLAB and Simulink for UAV and autonomous flight applications provides a comprehensive framework for developing, simulating, testing, and deploying medical delivery drones. The system includes two main nodes: the UAV control node and the hospital node, connected through a blockchain network that enables secure communication and transactions between the nodes

Output

The real-time output of a blockchain implementation in MATLAB and Simulink for a medical delivery drone would depend on the specific use case and system configuration. However, some examples of real-time output results that could be generated from the system include various factors they are as follows:

- *Location tracking.*
- *Temperature monitoring.*
- *Delivery status.*
- *Battery life.*
- *Flight telemetry.*

The real-time output for a medical delivery drone would depend on the drone's capabilities. Generally, a medical delivery drone is equipped with a Sensor, GPS, and a Camera, which provide real-time data on the drone's location, battery life, speed, and altitude. In addition, these drones are equipped with a payload that is used as a cargo container to deliver the packages to the recipient.

First and foremost is the "Location tracking". The drones provide real-time information and updates on the location. These updates can be accessed by both the sender and recipient to track the drone's progress.

I. Temperature monitoring: these drones should be monitored frequently to avoid damage.

II. Delivery status: once the cargo is delivered successfully, a real-time confirmation is sent to the sender and the receiver, knowing that the package/cargo has been delivered.

III. Battery life: the drone provides real-time information on the battery level status so that the pilot can plan accordingly for charging the battery or replacement.

IV. Finally, flight telemetry: the drones provide real-time information on the speed, accuracy, data path, and altitude.

Overall, the real-time output for a medical delivery drone is designed to provide operators with effective and efficient information about the drone status to ensure that critical medical supplies are delivered safely and efficiently.

8 | Conclusion

In conclusion, the block diagram of blockchain implementation in MATLAB and Simulink for UAV and autonomous flight applications provides a comprehensive framework for developing, simulating, testing, and deploying medical delivery drones [7]. The system includes two primary nodes, the UAV control node, and the hospital node, connected through a blockchain network that enables secure communication and transactions between the nodes.

The UAV control node is responsible for flight control and is equipped with a blockchain interface, flight control logic, and smart contract logic. In contrast, the hospital node is responsible for medical supply orders and payment transactions and is equipped with a blockchain interface.

The system also includes other components, such as simulation and testing. These provide a simulated environment for testing the UAV's flight and the blockchain network's behavior, as well as tools for automated testing and validation of the system's functionality. The Environment (MATLAB/Simulink) component provides the development environment for the autonomous flight algorithm's simulation, testing, and algorithm development.

Finally, the autonomous flight algorithm development component includes subcomponents such as obstacle avoidance, mission planning, and path following, which enable the UAV to navigate and perform its mission autonomously. Using blockchain implementation in MATLAB and Simulink, developers can efficiently and effectively develop, test, and refine the system, improving the medical delivery drone's reliability and reducing the risk of failure, ultimately enabling safer and more efficient medical deliveries.

Author Contribution

Appasamy Saraswathi was solely responsible for the conceptualization, analysis, and writing of the manuscript. The author led the exploration of the integration of blockchain technology with medical drones for improving healthcare delivery.

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Data Availability

No new data were generated or analyzed in this study. All information is included within the article.

Conflicts of Interest

The author declares no conflicts of interest regarding this work.

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